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The Mechanics of Agricultural Productivity and Economic Growth

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Increases in agricultural productivity contribute to national economic development and income growth in two major ways: they release labor resources for nonagricultural sectors and they supply an economic output above that consumed or used for further production in the agricultural sector—an "economic surplus" that can be transferred out of agriculture to provide capital for economic growth in the nonagricultural sectors. This paper suggests ways of measuring changes in agricultural output, input, and productivity and the contribution that increases in agricultural productivity can make to national income growth. Like Singer's article, it deals with mechanical aspects of economic growth.[1] It suggests an analytical framework for research on conditions influencing improvement in agricultural productivity.

HYPOTHETICA is an imaginary country, invented to illustrate the thesis of this paper. It is unique with respect to data available for analysis. It is a developing country with structural characteristics similar to many in the "real world." However, economic progress in improving agricultural productivity and national income in Hypothetica during the last two decades should not be considered typical for all low-income countries. Some in this group have had little if any growth as measured by rise in per capita income.

Agricultural Output

Agriculture in Hypothetica is shifting gradually from subsistence to commercial production. Half of the products produced in 1960 were marketed as compared with less than 40 percent in 1940.

Part I of table 1 shows that total agricultural output doubled from 1940 to 1960. All value data are in 1957–59 prices.

[1] W. H. Singer, "The Mechanics of Economic Development," *Indian Econ. Rev.*, August 1952.

TABLE 1.—*Agricultural output, input, and productivity in Hypothetica, 1940 and 1960, and percentage change*

Item	1940	1960	Percentage change
	Million dollars	*Million dollars*	
I. Agricultural output, total	10, 000	20, 000	100
A. Products, total	8, 000	16, 000	100
1. Subsistence	5, 000	8, 000	60
2. Marketed	3, 000	8, 000	167
a. Domestic	2, 000	5, 500	175
b. Export	1, 000	2, 500	150
B. Capital improvements, total	2, 000	4, 000	100
1. Land clearing, drainage, etc.	1, 500	3, 000	100
2. Livestock and draft animals	500	1, 000	100
II. Agricultural input, total	9, 000	15, 000	67
A. Inputs from within agriculture, total	7, 000	11, 000	57
1. Land	4, 000	6, 250	56
2. Land improvements	1, 000	1, 500	50
3. Working capital (seed, livestock, etc.)	500	1, 000	100
4. Labor of rural people	1, 500	2, 250	50
B. Inputs from outside agriculture, total	2, 000	4, 000	100
1. Fixed capital improvements	500	1, 500	200
2. Working capital (fertilizer, etc.)	1, 500	2, 500	67
III. Net agricultural output, total output less inputs from outside agriculture	8, 000	16, 000	100
IV. Productivity measures:			
A. Total agricultural output per unit of total input	*Dollars* 1. 11	*Dollars* 1. 33	20
B. Net agricultural output per unit of input from within agriculture	1. 14	1. 45	27
C. Agricultural products per acre	80	100	25
D. Agricultural products per worker	286	381	33
V. Land and labor inputs:	*Number*	*Number*	
A. Land, million acres	100	160	60
B. Agricultural workers, million	28	42	50

It is customary to include only products in measures of agricultural output. Such measures are meaningful. But land has been cleared, drained,

and irrigated, and farm buildings have been constructed in Hypothetica. The total acreage under cultivation has gone up 60 percent. Resources employed in agriculture, especially labor used to make farm improvements, have added to the capital stock of the country. Therefore, net additions to fixed capital are included in the total agricultural output of Hypothetica.

Products are "end products"—those available for domestic consumption, for export, or for adding to farm stocks. Crops fed to livestock are included in livestock products, so there is no double counting.

Obviously, most countries do not have data for measuring agricultural output precisely in all the above categories, but it is necessary to be aware of them and to know at least approximately the relative importance of each.

Subsistence products are valued at farm prices of marketed products. In the case of capital items, data refer to the annual value of their services.

Agricultural Input

Part II of table 1 shows that agricultural input increased 67 percent from 1940 to 1960. For land and capital goods, inputs refer to the value of annual services at 1957–59 prices. This also is true of labor.

Again, it may be noted that agriculture in Hypothetica is chiefly subsistence. A small, but slowly increasing, proportion of the input used annually is from nonagricultural sectors.

Even in Hypothetica where detailed data are available, it is difficult to decide on the appropriate values to place on inputs from within agriculture (land, fixed capital improvements on land, and labor) because there are few market sales of these inputs. We will return to problems of valuing inputs and outputs later.

Agricultural Productivity

Part III of table 1 indicates change in net agricultural output (agricultural sector output) from 1940 to 1960 with respect to the rest of the economy. Total agricultural output less inputs from other sectors is agriculture's contribution to the total economy. For illustrative purposes, we define this as gross national product (GNP). This definition of GNP, of course, differs from the usual one used in national accounts. Hypothetica's GNP from agriculture, or agricultural sector output, doubled from 1940 to 1960.

Part IV of table 1 shows changes in agricultural productivity. Total agricultural output per unit of total input increased 20 percent. But net agricultural output per unit of input from within agriculture increased 27 percent.

Most of the expansion in agricultural output resulted from the use of more inputs, mainly from within agriculture (labor, land, and capital improvements). Capital inputs purchased from nonagricultural sectors have become relatively more important. They have facilitated the application of new technology for increased agricultural output per worker and per acre.

Land area in agriculture increased 60 percent. Despite extension of the cultivated area to poorer lands, agricultural products per acre increased by a fourth. Labor input increased 50 percent. Agricultural products per worker increased a third.

Table 2 shows changes in the "input mix" associated with increased productivity. Land, including land improvements, is the major input. It accounted for over half of total input in 1960 as well as in 1940. Labor is a relatively minor input measured in value terms, a reflection of the abundance of labor relative to other input items. Capital has increased its importance.

Land and labor in agriculture have very low values in alternative uses. It is of interest to observe the additional returns from the additional nonagricultural inputs. If it can be assumed that the additional land and labor used were "costless," then the increased capital input of $2 billion was

TABLE 2.—*Percentage distribution of inputs, Hypothetica, 1940 and 1960, and percentage change in value of inputs*

Input categories	Items from table 1	Percentage distribution		Percentage change, 1940 to 1960
		1940	1960	
Land and land improvements	II-A-1, II-A-2	55	52	53
Labor	II-A-4	17	15	50
Capital	II-A-3, II-B	28	33	100
Total		100	100	67

associated with increased output of $10 billion, or a ratio of 1 to 5.

Subsistence and Market Sectors

Subsistence and market sectors of agriculture need to be considered separately (table 3). The market sector, of course, is the source of economic surpluses that can be transferred from agriculture to other sectors.

In 1940, value of agricultural products marketed exceeded value of purchased input by $1 billion. This $1 billion, plus output retained in agriculture and value at $7 billion, meant that agriculture's contribution to the GNP was $8 billion. Agriculture supplied food and other products for consumption in nonagricultural sectors. In addition, it was an important earner of foreign exchange as the value of agricultural exports was much larger than that of agricultural imports.

In 1960, total agricultural output exceeded total input by $5 billion, $4 billion more than in 1940. Hypothetica has an effective taxation program for capturing a substantial part of the increased product resulting from increased agricultural productivity, and a development program for using it in nonagricultural sectors. Of the increase in the economic surplus, $3 billion was retained in the agricultural sector. The remaining $1 billion was taxed away from agriculture.

Transfer of agricultural income into nonagricultural sectors can, of course, take place in other ways:

1. Real prices of food and other agricultural products may decline. This indirectly reduces production costs in industry and other sectors where wage rates are influenced by food costs.

2. Landlords and others who share in agricultural income may transfer some of this income into nonagricultural uses by making investments in industry.

3. Agricultural people who move into nonagricultural sectors may "take along" or transfer money from agriculture to other sectors. Agriculture, of course, pays costs of rearing, educating, and training people who migrate to urban areas.

TABLE 3.—*Value of agricultural output and input by sectors. Hypothetica, 1940 and 1960, and percentage change*

Sector	Items from table 1	1940	1960	Percentage increase
		Million dollars	*Million dollars*	
MARKET				
Agricultural products.	I-A-2	3,000	8,000	167
Purchased inputs	II-B	2,000	4,000	100
Difference		1,000	4,000	300
SUBSISTENCE				
Agricultural output	I-A-1, I-B.	7,000	12,000	71
Inputs	II-A	7,000	11,000	57
Difference			1,000	
TOTAL				
Agricultural output	I	10,000	20,000	100
Agricultural input	II	9,000	15,000	67
Difference		1,000	5,000	400

TABLE 4.—*Total agricultural production, per capita consumption, and population, Hypothetica, 1940 and 1960*

Items	1940	1960	Percentage increase
Total production million dollars	8,000	16,000	100
Exports do	1,000	2,500	150
Difference do	7,000	13,500	93
Imports do	500	1,500	200
Total available for domestic use do	7,500	15,000	100
Per capita consumption dollars	75	91	21
Total population million	100	165	65

Markets and Consumption Levels

Market demand for agricultural products has increased rapidly with population growth and higher per capita incomes, especially in urban areas. Although total agricultural output has increased at a compound annual rate of 3.5 percent a year, it has been necessary to increase imports of food in order to meet increased economic demand and keep the cost of living stable. Per capita consumption of agricultural products has gone up 21 percent, about 0.8 percent a year (table 4).

The growth rate in total demand for agricultural products is equal to population growth rate (p), plus growth rate for per capita income (g) times income elasticity of demand (n). The population growth rate for Hypothetica has been relatively rapid, about 2.6 percent a year. Per capita income has increased at about 1.3 percent a year. Income elasticity of demand for agricultural products is relatively high, approximately 0.8. By substituting appropriate numbers in the equation, $D=p+gn$, it can be observed that total demand for agricultural products increased at a rate of 3.64 percent a year. Domestic demand for agricultural products has increased a little more rapidly than agricultural production.

Larger agricultural imports have been financed by food aid programs. Hypothetica has had difficulty earning enough foreign exchange to finance imports of capital goods required for industrial development. If it had not been for food aid programs, industrial growth would have been retarded, more people would have remained in agriculture, and national income growth would have been slower.

National Income Growth

As in other developing countries, and in developed countries too, per capita incomes in Hypothetica average much lower in agriculture than in nonagricultural sectors (table 5).

Two things need to be noted with regard to the above data: (1) $1 billion of the increase in net product of agriculture was transferred to nonagricultural sectors; (2) the large percentage rise in per capita income for the total population resulted partly from transfer of people from agriculture, where incomes are low, to nonagricultural sectors where they are higher.

The gain in agricultural productivity was large enough to cause incomes per person to rise by about as large a percentage in agriculture as in other sectors, even though a part of the gain was transferred to nonagricultural sectors.

A large part of total output (GNP) was used for capital investment or new development, one-fourth in 1940 and 26 percent in 1960. These large investments have helped make possible a high national output growth rate, about 4.5 percent a year.

In 1940, one-half of total capital investment originated from output in the agricultural sector.

TABLE 5.—*Gross national product, capital investment, and income, total and per capita, Hypothetica, 1940 and 1960*

Item	1940	1960	Percentage increase
Agricultural sector:			
GNP from agriculture ... million dollars	8,000	16,000	100
Capital investment ... do	2,000	4,000	100
Net income for consumption ... do	6,000	12,000	100
Net income per person ... dollars	86	114	33
Population ... million	70	105	50
Nonagricultural sectors:			
GNP from rest of economy ... million dollars	8,000	22,200	177
Capital investment ... do	2,000	6,000	200
Net income for consumption ... do	6,000	16,200	170
Net income per person ... dollars	200	270	35
Population ... million	30	60	100
Total economy:			
GNP ... million dollars	16,000	38,200	139
Capital investment ... do	4,000	10,000	150
Net income for consumption ... do	12,000	28,200	135
Net income per person ... dollars	120	171	42
Population ... million	100	165	65

In 1960 the agricultural sector's contribution to total investment decreased to 40 percent. Growth in national income, of course, resulted from increased productivity in other sectors as well as from increased productivity in agriculture.

Transfer of Labor Resources

In terms of employment, Hypothetica was chiefly an agricultural country in 1940 and continued to be so in 1960, although there was a large net migration from agriculture to other sectors (table 6).

The population growth rate was 2.6 percent per year for the country as a whole. Population in nonagricultural sectors doubled while that in agriculture increased by one-half. Agriculture accounted for 64 percent of total population in 1960 as compared with 70 percent in 1940. Population and employment in nonagricultural sectors in-

TABLE 6.—*Distribution of total population by employment sectors, Hypothetica, 1940 and 1960*

Sector	1940	1960			
		With migration to nonfarm sectors		With no migration	
	Million persons	*Million persons*	*Percent*	*Million persons*	*Percent*
Agriculture	70	105	64	115.5	70
Nonagriculture	30	60	36	49.5	30
Total	100	165	100	165.0	100

creased 3.5 percent a year while that in agriculture increased about 2.1 percent a year. We assume that 40 percent of the total population in both periods constitutes the work force. Had we not assumed a constant age distribution for both periods, the population and employment growth rates would have differed.

Net movement of people from agriculture to other sectors during the 1940–60 period (10.5 million) was equivalent to 15 percent of the total population in agriculture in 1940, or to about 10 percent of the total population. About 18 percent of the labor force in nonagricultural sectors in 1960 were people who moved out of agriculture during the 1940–60 period.

The contribution of agriculture to the labor force in nonagricultural sectors was large. But movement of people out of agriculture would have been even larger if employment opportunities in the other sectors had increased at a faster rate. Income levels in nonagricultural sectors average much higher than those in agriculture. However, Hypothetica has done well to increase employment in nonagricultural sectors by 3.5 percent a year.

In most developing countries population growth rates are higher in agriculture than in other sectors. If the population growth rate for agriculture had been higher and that for other sectors had been lower in Hypothetica, a much larger net migration out of agriculture would have been necessary to achieve the 100 percent growth in nonagricultural population and the 50 percent growth in agricultural population.

Investments made by rural people to improve their education and skills, of course, are transferred out of agriculture when they move to nonagricultural sectors. But even more important is the fact that agriculture pays the costs of rearing rural people who move from rural to urban areas. As suggested by Kuznets,[2] if it is assumed that the cost of rearing, educating, and training rural people is equal to the income received per person in the agricultural sector over a 10-year period (about $950 per person), net migration of 10.5 million people from agriculture to other sectors represents transfer of investment in the "human agent" of about $10 billion from agriculture to other sectors during the 1940–60 period.

Valuation Problems

Economists are faced with difficult problems in measuring agricultural output, input, and productivity in Hypothetica because of the subsistence nature of agriculture.

A reasonably good job in valuing agricultural products can be done if substantial quantities move to markets that establish prices for them. However, market-pricemaking forces operate imperfectly in Hypothetica.

Values placed upon inputs of land and fixed capital improvements (and outputs in the form of land improvements) are based on prices established by relatively few market transactions. These prices, too, are influenced by imperfect markets. An additional problem is that of deciding how to value the annual service of land and other fixed investments. Obviously, it is necessary to assume a capitalization or interest rate. Interest rates also are likely to be influenced by imperfect market conditions, with many buyers and few sellers.

Finally, there is the question of how to value labor input when most agricultural workers are self-employed. It is usual to impute values for labor of the self-employed chiefly on the basis of wage rates of hired workers.

Do these difficulties in placing values on inputs and outputs in agriculture mean that estimating changes in agricultural output, input, and productivity is a meaningless exercise? The answer, of course, is *no*. By going through this exercise,

[2] Simon Kuznets, "Economic Growth and the Contribution of Agriculture: Notes on Measurement," *Internatl. Jour. Agrar. Affairs*, vol. 3, pp. 59–75, 1961.

country by country, much can be learned about the magnitudes of the variables affecting agricultural output and productivity, the obstacles to economic progress in agriculture, and the role of agriculture in national economic growth.

The values placed on inputs from within agriculture are imputed values, and these influence estimates of the relative importance of land, labor, and capital in the "input mix." Labor, for example, may account for a small part of total input in less developed countries because it has a low value per unit. The reverse is true of capital. Thus, agriculture in less developed countries uses large quantities of labor and small quantities of capital as compared with agriculture in the highly developed countries.

There appears to be no escape from the general conclusion that the physical volume of capital must increase relative to that of labor in order to improve agricultural productivity. However, if additional capital is to be most effective, it must be in the forms and combinations required for the application of improved technology.

Conditions Influencing Productivity

It is difficult to develop precise measures of change in agricultural productivity and the contributions that such gains make to national economic growth. But these tasks are simple, compared with measurement of the conditions that cause gains in agricultural productivity.

The sources or "proximate causes" of increased agricultural output are apparent. For example, agricultural output depends upon the level of technology and quantities of land, labor, and capital inputs. In Hypothetica the volume of conventional inputs (land, labor, and capital) increased 67 percent, but output per unit of input (technology) increased 20 percent. However, the combination of inputs was changed with the input of additional capital goods. A substantial part of the additional output might be attributed to change in the input mix and new or improved inputs.

Perhaps the most effective way to analyze the factors affecting agricultural output and productivity is to consider them in the traditional supply and demand framework. On the supply side the following need to be considered:

1. Traditions and attitudes affecting farming methods and practices. Can people be induced by economic incentives to change customs and practices?

2. Available technology. Do farmers have access to combinations of improved practices or production techniques which are adapted for soil and climatic conditions?

3. Diffusion of knowledge about improved technology. Farmers obviously need to know about improved production practices if they are to adopt them.

4. Supplies of additional inputs, including land, labor, and capital. Most improved production methods, even better seeds, require additional capital inputs. Are these available, and if so, at what price?

5. Tenure, credit, taxation, and marketing systems, with reference to how they influence production and marketing costs.

On the demand side, the following merit attention:

1. Population and income growth in nonagricultural sectors that causes demand for farm products to increase and to change in composition.

2. Export markets for agricultural products. These may expand less than domestic markets, depending upon the product.

3. Increases in subsistence demand resulting from farm population growth.

4. Tenure, credit, taxation, and marketing systems, with regard to how they affect prices received by farmers and the quantities of products that can be sold at these prices.

5. Transportation, storage, and processing facilities that influence demand and prices of farm products at the farm level.

In Conclusion

First, factors that affect supply and demand for agricultural products are interrelated and often cannot be classified neatly in either the demand or supply category. For example, improvement in prices and expansion in demand for farm products may cause farm people to conserve soil and water resources, which in turn will lead to lower

unit costs of production and add to the supply of agricultural inputs.

Second, the distinction between additional output resulting from higher levels of productivity and additional output resulting from the use of additional inputs is important. If agriculture is to contribute to economic growth, it must become more productive as measured by output per unit of input. Raising agricultural output by employing more inputs from the nonagricultural sectors is not sufficient.

Third, changes in the input mix and a larger output usually are associated with increased productivity. In Hypothetica, agricultural output increased 5 percent on the average for each 1 percent increase in total output per unit of total input. The experience of the United States has been similar. In Hypothetica, demand for agricultural products kept pace with increase in supply. Increased output and productivity did not depress prices of products. But this will not always be true for developing countries.

Finally, economic progress in agriculture and in other sectors is interdependent. There is nothing magic about productivity gains in agriculture. Gains in nonagricultural sectors are equally important. In Hypothetica, nonagricultural sectors helped improve agricultural productivity by making available larger supplies of fertilizer, tools, and machines, and by providing employment opportunities for rural people. Growth in domestic and foreign markets made expansion in agricultural output profitable and thereby contributed to gains in agricultural productivity.

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